

DEVELOPMENT OF STAINLESS STEEL TROLLEY

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for the award of
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Faculty of Mechanical Engineering
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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this project and in my opinion this project is satisfactory in terms of scope and quality for the award of Diploma in Mechanical Engineering

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Date:

STUDENT'S DECLARATION

I hereby declare that the work in this report is my own except for quotations and summaries which have been duly acknowledged. The report has not been accepted for any diploma and is not concurrently submitted for award of other diploma.

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ABSTRACT

This report presents about trolley that always been used especially in lab. This trolley is a device which is important in order to ease transportation and to decrease the load when we want to lift or transport heavy items from one place to another. The idea of the fabricating of this trolley is based on student's creativity. The selection of suitable materials in the fabricating of this trolley is a loaded material which has minimum weight, long life-span and can detain heavy load. Materials are proposed for the fabrication of the trolley is a stainless steel material. In this report, we'll also be having more to the fabrication of this trolley.

ABSTRAK

Laporan ini membentangkan tentang troli yang sering kali digunakan terutamanya di dalam makmal. Troli merupakan suatu perkakas yang penting untuk memudahkan pergerakan dan meringankan beban ketika hendak mengangkat atau mengubah barang yang berat dari satu tempat ke satu tempat. Idea pembentukan troli ini berdasarkan kreativiti pelajar sendiri. Pemilihan bahan yang sesuai untuk digunakan bagi pembentukan troli ini merupakan bahan yang mempunyai berat yang ringan, jangka hayat yang tahan lama dan boleh menahan beban yang berat. Bahan yang dicadangkan untuk pembentukan troli ini merupakan material jenis stainless steel. Dalam laporan ini juga akan lebih memfokuskan kepada pembentukan troli.

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LIST OF SYMBOLS

ϵ	Strain
σ	Stress (N/m^2)
E	Young's Modulus = σ / ϵ (N/m^2)
y	Distance of surface from neutral surface (m).
R	Radius of neutral axis (m)
I	Moment of Inertia (m^4 - more normally cm^4)
Z	Section modulus = I/y_{\max} (m^3 - more normally cm^3)
M	Moment (Nm)
W	Total load on beam (kg) or (N as force units)
F	Concentrated force on beam (N)
S	Shear Force on Section (N)
L	Length of beam (m)
x	Distance along beam (m)

LIST OF ABBREVIATIONS

AL	Aluminium
AISI	The American Iron and Steel Institute
ASTM	American Society for Testing and Materials
CAD	Computer Aided Design
MIG	Metal Inert Gas Welding
PPE	Personal Protective Equipment
UHMWPE	Ultra high molecular weight polyethylene
SMAW	Shielded metal arc welding
UMP	Universiti Malaysia Pahang

CHAPTER 1

INTRODUCTION

1.1 PROJECT SYNOPSIS

1.1.1 General Project Synopsis

The project involves designing and fabricating a Trolley. As the Diploma final year project allocates the duration of 1 semester, this large man-hour project therefore requires significant efforts of the students to participate. Basically the entire trolley could be divided into three stages, which are concept review and development, designing and fabrication.

The trolley is equipped by using stainless steel 304 2B material which include, rectangular plate steel, round hollow steel, and wheels in manufacturing process by perform MIG welding to joint the parts and etc. The advantages of the proposed trolley to be developed can be seen to be moved such that, man are offered to make their task easier since the trolley will facilitate them to transfer heavy items for instance, computer and etc.

The process of development is initiated from designing the shape of the trolley by considering the function as well. In order to produce user friendly product that is suitable to the consumer, consideration to the ergonomic factor is taken into account. It involves the measurement process before the materials are cut into pieces before joined together.

1.1.2 Specific Project Synopsis

My project title is Development of Stainless Steel Trolley. The project involves small analysis of the Trolley frame body and fabrication of the trolley itself with concerns regarding strength, durability, ergonomic factor, and convenience. Test need to be done to verify the strength of the trolley right before the fabrication process to avoid material and fund wasting. The projects prerequisites are Static, Dynamic and Strength of Material. Overall, the project will meet acquire skills of design, analysis, and fabrication.

1.2 PROBLEM STATEMENT

The concept of the trolley is to facilitate man for loading items. This trolley will primarily help staff especially members of Faculty of Mechanical Engineering to load and unload heavy items that's need trolley for convenience. Members are facing problem while the need to bring things from one place to another due to unavailability of trolley. Thus, with the development of this trolley, it is hope that it can contribute to give them ideas how to overcome problem in loading items by choose the better way in facilitate their routine at University Malaysia Pahang especially for Faculty of Mechanical Engineering staff.

1.3 PROJECT SCOPE OF WORK

- 1.3.1 Literature Review:** Valuable data are searched and gathered. Considering the shape of the trolley in terms of its complexity and method to produce.
- 1.3.2 Sketching & Designing:** Sketching and designing using Solidwork software in creating the design of the trolley.
- 1.3.3 Fabrication:** Fabricate and produce the trolley by using all necessary manufacturing process such as welding, cutting, grinding and etc.
- 1.3.4 Testing & Evaluation:** Simulate the mechanism of the trolley produce is in line with the expected function to be.

1.4 PROJECT OBJECTIVES

1.4.1 General Objectives

Diploma final year project objective is to practice the knowledge and skill of the student that have been gathered before in solving problem using academic research, to born an engineer that have enough knowledge and skill. This project also important to train and increase the student capability to get know, research, data gathering, analysis making and then solve a problem by research or scientific research.

The project also will educate the student in communication like in a presentation and educate them to defend their research in the presentation. The project also will generate students that have capability to make a good research report in thesis form or technical writing. This project also can produce and train student to capable of doing work with minimal supervisory and more independent in searching, detailing and expanding the experiences and knowledge.

1.4.2 Specific Project Objectives

The project objectives are to design trolley that is suite to its application especially for loading items and to minimize the manufacturing cost by minimize the complexity of the trolley and simulate the material used with cheaper material but having high strength and endurance.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Literature Review															
Design & Measurement consideration															
Acquisition & Material preparation															
Methodology study															
Fabrication															
Evaluation & Improvement															
Report writing															
Presentation															

Table 1: Project Schedule

1.5 PROJECT FLOW CHART

For the diagram as shown as below, the project starts with literature review and research about the title. This consist a review of the concept of trolley, trolley system, trolley features and type of trolley used in various fields such as food industries, hospital and etc. These tasks have been done through research on the internet, books and others sources.

After gathering all the relevant information, the project undergoes design process. In this step, from the knowledge gather from the review is use to make a sketch design that suitable for the project. After several design sketched, design consideration have been made and one design have been chosen. The selected design sketched is then transfer to solid modelling and engineering drawing using Solidworks program. The materials and the measurement needed for the trolley listed down and calculated to give an ergonomic shape of the trolley.

Next, after the needed material is listed, acquisition step take places. There are only a few materials that need to buy such as wheels. Some of the needed material is well-prepared by the university.

After all the parts needed had been gathered, the project proceeds to next step that is fabrication process. The finished drawing and sketching is used as a reference by following the measurement and the type of materials needed. The fabrication process that involved is cutting, welding, and others. If all the parts had been processed, the parts are joined together to produce full-scaled trolley. Here come the testing and evaluation process. The trolley will be test to see if it fulfills the requirement such as ergonomic aspect, safety, strength and manoeuvrability. During the testing, if problem occur such as malfunction or unstable platform, the trolley will step back to the previous process, where the error is fixed. The trolley is expected to have an error that may cause the part to be re-designed and re-fabricate again.

After all the parts had been joined together, here comes the last phase of process that is data discussion. In data discussion, the draft report and all the related articles are gathered and hand over to the supervisor for error checking. The finish product will be compared with the report to make sure that there is no mistake on both project and report.

After the product and the report had been approved by the supervisor, the report is rearrange and print out to submit at the supervisor, the project coordinator and faculty of Mechanical Engineering. In this stage, the final presentation was also being prepared and waited to be present.

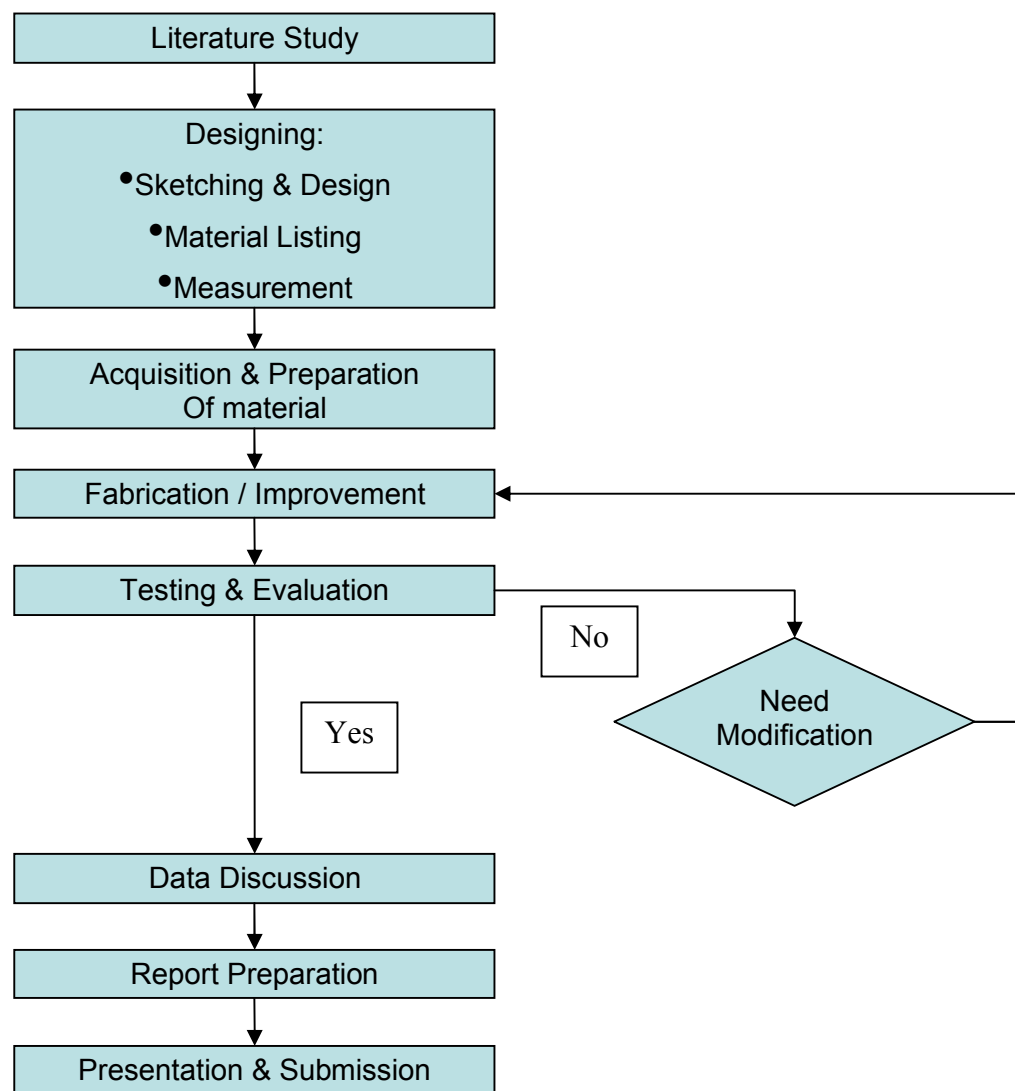


Figure 1.1: Project Flow Chart

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

The trolley is a mechanism that allowed man to transfer their heavy items such as computers, files and etc to other places. It's help man to do their work without having a problem due to the heavy loading. Its also helps to reduce pain in waist, back, hand and feet. No mater how light the loading is, people usually will suffocate a large pain in their body if lifting the items in many times. So, this is when the people rely upon a trolley that can do items transferring many times with just a little effort. From the statement above conclude that the trolley playing a major role as an items transferring mechanism for people without having a problem of doing that. A trolley also functioned as a helper to people to hold items orderly while transferring between rough lands.

2.2 PAPER REVIEW

2.2.1 Trolley types and functions

- (i) **Food Trolley:** a small table on wheel or castor that typically used to convey foods and drinks.
- (ii) **Supermarket trolley:** a large metal basket or frame on wheels used for transporting heavy and unwieldy items.
- (iii) **Luggage trolley:** a frame on wheel used to transporting heavy luggage at airport or railway station.

- (iv) **Hospital trolley:** a tray on wheels for transporting icebox for organ, surgery items and others.
- (v) **Full-storage trolley:** a cabinet on wheel for keeping workshop tools and transporting them easily.
- (vi) **Lightweight portable trolley:** a platform on wheels for transporting wide and heavy items in workshop, office, warehouse and etc.

2.3 TECHNICAL REVIEW

2.3.1 Pictures



Figure 2.1: Hospital Trolley



Figure 2.2: Full-storage Trolley



Figure 2.3: Luggage Trolley



Figure 2.4: Lightweight Portable

2.4 BASIC PARTS

- 2.4.1 **Wheel:** Usually made from rubber that joined together with the bolt and nut with steel frame to ensure strength.
- 2.4.2 **Body:** For outdoor use such as warehouse or workshop that requires full strength of body, wire frame or sheet metal body is used. Some trolley doesn't have any body on it on purpose.
- 2.4.3 **Handle Bar:** Usually all the trolley must have handle to provide less effort while using the trolley due to heavy it's loading.

2.5 JOINING METHOD

Joining involves in assembly stage. Commonly used method to join metal part is Metal Inert Gas (MIG) welding.



Figure 2.5: Metal Inert Gas (MIG) Welding

2.5.1 Metal Inert Gas (MIG) Welding

MIG (Metal Inert Gas) or as it even is called GMAW (Gas Metal Arc Welding) uses an aluminum alloy wire as a combined electrode and filler material. The filler metal is added continuously and welding without filler-material is therefore not possible. Since all welding parameters are controlled by the welding machine, the process is also called semi-automatic welding.

The MIG-process uses a direct current power source, with the electrode positive (DC, EP). By using a positive electrode, the oxide layer is efficiently removed from the aluminum surface, which is essential for avoiding lack of fusion and oxide inclusions. The metal is transferred from the filler wire to the weld bead by magnetic forces as small droplets, spray transfer. This gives a deep penetration capability of the process and makes it possible to weld in all positions. It is important for the quality of the weld that the spray transfer is obtained.

There are two different MIG-welding processes, conventional MIG and pulsed MIG:

- a) Conventional MIG uses a constant voltage DC power source. Since the spray transfer is limited to a certain range of arc current, the conventional MIG process has a lower limit of arc current (or heat input). This also limits the application of conventional MIG to weld material thicknesses above 4 mm. Below 6 mm it is recommended that backing is used to control the weld bead.
- b) Pulsed MIG uses a DC power source with superimposed periodic pulses of high current. During the low current level the arc is maintained without metal transfer. During the high current pulses the metal is transferred in the spray mode. In this way pulsed MIG is possible to operate with lower average current and heat input compared to conventional MIG. This makes it possible to weld thinner sections and weld much easily in difficult welding positions.

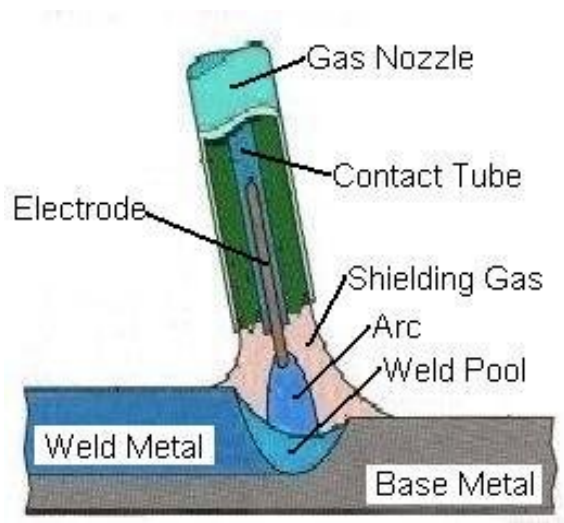


Figure 2.6: Schematic of Metal Inert Gas (MIG) Welding

GMAW is frequently referred to as MIG welding. MIG welding is a commonly used high deposition rate welding process. Wire is continuously fed from a spool. MIG welding is therefore referred to as a semiautomatic welding process. ^[1]

There are some advantages and disadvantages in using MIG welding:

The advantages of MIG welding

- All position capability
- Higher deposition rates than SMAW
- Less operator skill required
- Long welds can be made without starts and stops
- Minimal post weld cleaning is required

The disadvantages of MIG welding

- Costs money of consumable, such as tips and nozzles
- Is not worth a dang on paint, rust, or dirty surfaces
- No good for thick steel because it does not get the proper penetration

2.6 SHEARING PROCESS

Shearing is a metalworking process which cuts stock without the formation of chips or the use of burning or melting. Strictly speaking, if the cutting blades are straight the process is called shearing; if the cutting blades are curved then they are shearing-type operations. The most commonly sheared materials are in the form of sheet metal or plates; however rods can also be sheared. Shearing-type operations include: blanking, piercing, roll slitting, and trimming. ^[3]

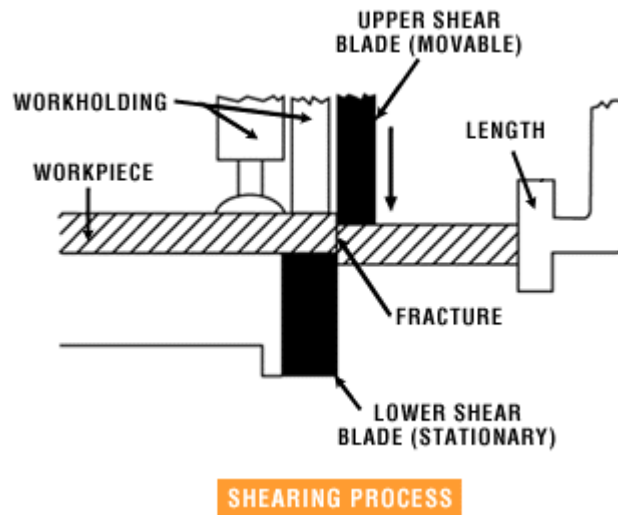


Figure 2.7: Shearing Process

Materials that are commonly sheared include Aluminum, Brass, Bronze, Mild steel and Stainless steel. The shearing process uses three types of tool systems. They are used for shearing:

- Sheet metal and plate using a squaring or bow tie shear
- Angle materials using an angle shear, and
- Bar stock using a bar shear.



Figure 2.8: Shearing Machine

2.7 BENDING PROCESS

Bending is a process by which metal can be deformed by plastically deforming the material and changing its shape. The material is stressed beyond the yield strength but below the ultimate tensile strength. The surface area of the material does not change much. Bending usually refers to deformation about one axis.

Bending is a flexible process by which many different shapes can be produced. Standard die sets are used to produce a wide variety of shapes. The material is placed on the die, and positioned in place with stops and/or gages. It is held in place with hold-downs. The upper part of the press, the ram with the appropriately shaped punch descends and forms the v-shaped bend.

Bending is done using Press Brakes. Press Brakes normally have a capacity of 20 to 200 tons to accommodate stock from 1m to 4.5m (3 feet to 15 feet). Larger and smaller presses are used for specialized applications. Programmable back gages, and multiple die sets available currently can make for a very economical process. ^[4]



Figure 2.9: Bending Machine

2.8 DRILLING

Drilling is easily the most common machining process. One estimate is that 75% of all metal-cutting material removed comes from drilling operations. Drilling involves the creation of holes that are right circular cylinders. This is accomplished most typically by using a twist drill, something most readers will have seen before. The chips must exit through the flutes to the outside of the tool. As can be seen in the figure, the cutting front is embedded within the work piece, making cooling difficult. The cutting area can be flooded, coolant spray mist can be applied, or coolant can be delivered through the drill bit shaft. ^[5]

2.8.1 Drill Press

A typical manual drill press is shown in the figure below. Compared to other powered metal cutting tools, a drill press is fairly simple, but it has evolved into a versatile necessity for every machine shop.

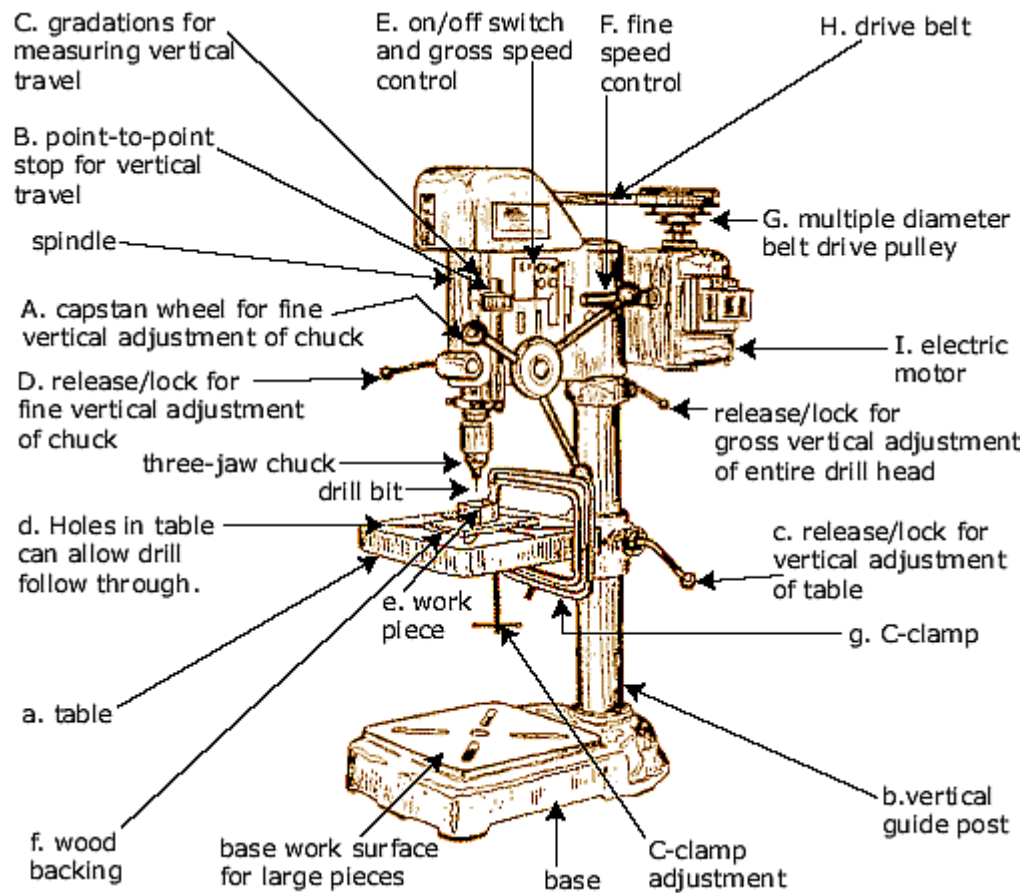


Figure 2.10: Drill Press Machine

2.9 GRINDING PROCESS

Grinding is a finishing process used to improve surface finish, abrade hard materials, and tighten the tolerance on flat and cylindrical surfaces by removing a small amount of material. Information in this section is organized according to the subcategory links in the menu bar to the left.

In grinding, an abrasive material rubs against the metal part and removes tiny pieces of material. The abrasive material is typically on the surface of a wheel or belt and abrades material in a way similar to sanding. On a microscopic scale, the chip formation in grinding is the same as that found in other machining processes.

The abrasive action of grinding generates excessive heat so that flooding of the cutting area with fluid is necessary. [6]



Figure 2.11: Grinder

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

Project methodology is a body of practices, procedures and rules used by those who work in a discipline or engage in an inquiry and a set of working methods. In this chapter, I will explain about the process that involved during the fabrication process. I also will explain about the design and analysis that had been chosen to be as the final idea to be producing or fabricate. All the fabrication process in this project is going to be explained in details.

3.2 DESIGN

The Design of the Trolley must be compliance to several aspects. The design consideration must be done carefully so the design can be fabricated and the parts are all functioning. The aspects that must be considered in designing the trolley are:

- 3.2.1 Strength:** Must have certain strength to ensure that it can load heavy items.
- 3.2.2 Ergonomic Factors:** Trolley must be user friendly as easy and convenience.
- 3.2.3 Suit to environment:** The trolley must be suitable to be use in factory area.

3.3 DRAWING

The drawings are divided into two categories, which are:

3.3.1 Sketching: All the ideas for the trolley fabrication are sketched on the paper first to ensure that idea selection can be made after this, and

3.3.2 CAD Drawing: The final idea is drawn into the CAD drawing format with details features.

3.4 DESIGN SPECIFICATION

The design of the Trolley must be considered that it can endure several specifications, which are two platform trolley, maximum load for the platform: 8kg –10kg, overall materials are 1 in X 31.5 in hollow steel (4 hollow steel), 870mm X 570mm X 1.2mm Stainless Steel plate (2 plate), and also wheels (4 wheels) and lastly convenience.

3.5 SKETCHING DRAWING SELECTION

From the existing ideas, only three sketching that had been chosen to be considered as the final ideas, which are:

3.5.1 Sketching 1

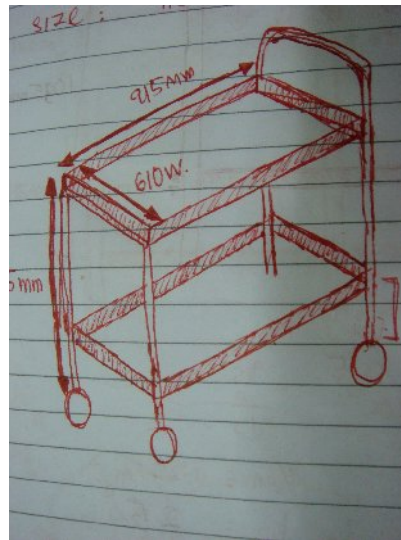


Figure 3.1: Sketching 1

3.5.2 Sketching 2

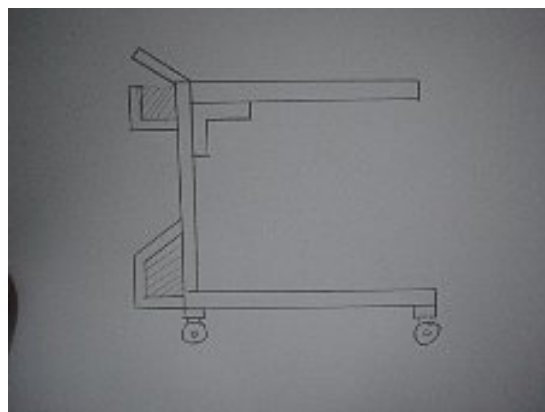


Figure 3.2: Sketching 2

3.5.3 Sketching 3



Figure 3.3: Sketching 3

3.6 SKETCHING SELECTION

3.6.1 Suggested Drawing

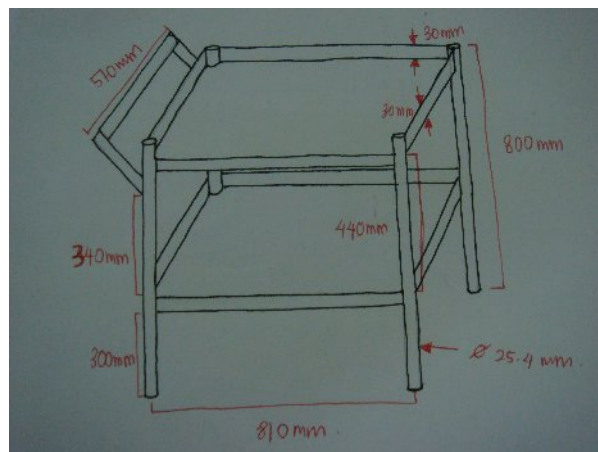


Figure 3.4: Sketching 4

I'm choosing this sketching as my project concept is because it is simple but yet convenience. Thus, the support bar was located on the right spot of the pressure point.

3.7 COMPUTER AIDED DESIGN DRAWING

After a design has been selected, the next step in the designing process is dimensioning. The dimensioning is base on relevant dimensions and also referring to the existence trolley so that the design is fit into others part.

After dimensioning, the engineering drawing of the design is drawn using Solidworks application, at this stage solid modelling method is used. Part by part solid modelling created according to the dimension done before, after all part created, the 3D model is assembled with each other base on the design.

3.8 OVERALL VIEW OF THE DESIGN

3.8.1 Design Descriptions

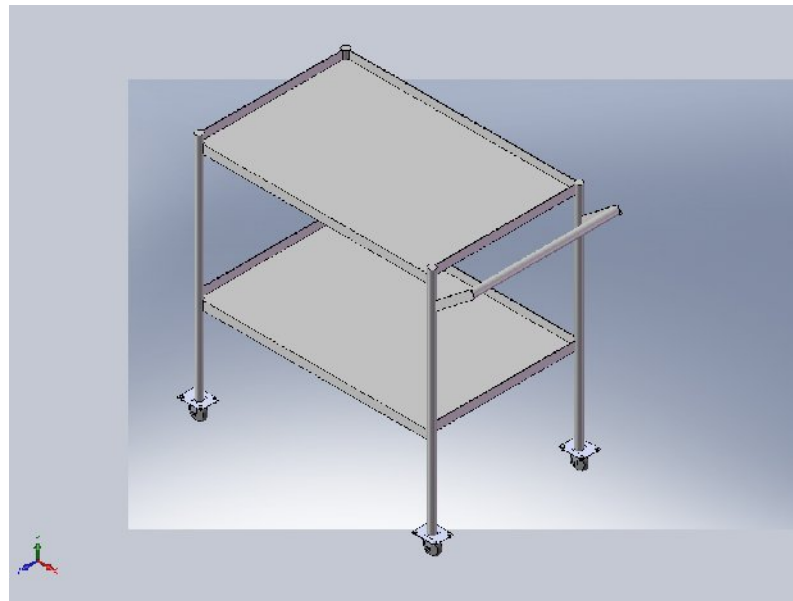


Figure 3.5: CAD Drawing

This design show that the final idea of the Stainless Steel Trolley. Additional base for tire also were added to make sure that the trolley can be easily to move.

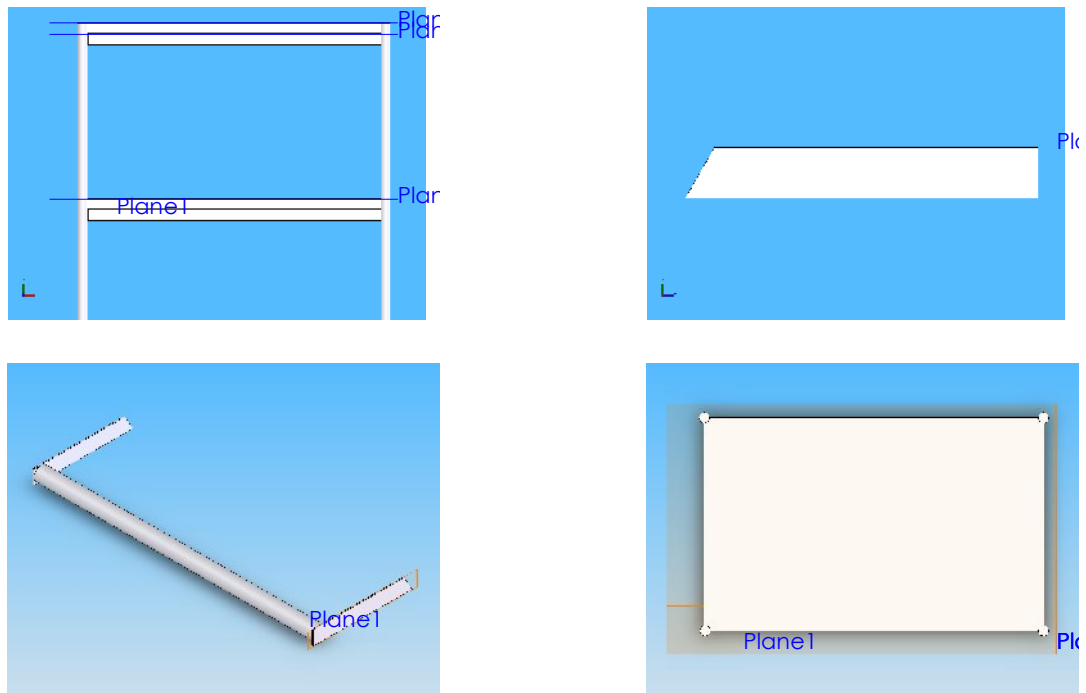


Figure 3.6: Explode CAD Drawing

3.9 CALCULATION

3.9.1 Engineering strain on a sheet during bending

$$\begin{aligned}
 \varepsilon &= \frac{1}{(2R/T) + 1} \\
 &= \frac{1}{(2(3)/1.2\text{mm}) + 1} \\
 &= 0.1667\text{mm}
 \end{aligned}$$

3.9.2 Bend Allowance

$$B = \frac{AJI}{180} (R + Kt)$$

$$B = \frac{95JI}{180} (0.089 + 0.047/3)$$

$$= 0.174\text{in}$$

3.9.3 Bend Radius

$$R = \frac{180B}{AJI} - Kt$$

$$R = \frac{180(0.174)}{95JI} - (0.047/3)$$

$$= 0.089\text{in}$$

3.9.4 Bend Force

$$P = \frac{KLS t^2}{V(1000)}$$

$$P = \frac{(1.3)(16.32)(0.047)^2(45)}{6}$$

$$= 0.35 \text{ ton}$$

3.9.5 Cutting Force

$$\begin{aligned}
 \text{For contours steel} \quad \text{TN} &= \frac{\text{SLT}}{2000} \\
 &= \frac{(241.3)(20.08)(0.047)}{2000} \\
 &= 0.114 \text{ ton}
 \end{aligned}$$

$$\begin{aligned}
 \text{For hollow} \quad \text{TN} &= \frac{\text{JIDST}}{2000} \\
 &= \frac{\pi (241.3)(0.047)(1)}{2000} \\
 &= 0.0178 \text{ ton}
 \end{aligned}$$

3.10 FABRICATION PROCESS

After designing phase, comes fabrication process. These processes is about using the material Selection and make the product base on the design and by followed the design dimension. Many methods can be used to fabricate a product, like welding, fastening, cutting, drilling and many more method. Fabrication process is difference from manufacturing process in term of production quantity. Fabrication process is a process to make only one product rather then manufacturing process that focus to large scale production. In the project fabrication process needed to make the base plate, framework of display board and display board. Fabrication process was used at the whole system production. This was include part by part fabrication until assembly to others component.

3.10.1 Process Involve

In order to make the design come to reality, fabrication process needs to be done first. The fabrication process starts from dimensioning the raw material until it is finish as a desired product. The processes that involved are:

- **Measuring:** Materials are measured to desired dimensions or location.
- **Marking:** All measured materials need to be marked to give precise dimension.
- **Cutting:** Marked materials are then cut into pieces.
- **Joining:** Materials joined by the method of welding and using bolt nuts.
- **Drilling:** Marked holes are then drilled to make holes for bolts.
- **Finishing:** Any rough surface cause by welding spark were grind to give smooth and safe surface.

3.10.2 Material of The Project

Material of the project is totally using stainless steel according to the title given which is Development of Stainless Steel Trolley 304. Grade 304 is the standard "18/8" stainless; it is the most versatile and most widely used stainless steel, available in a wider range of products, forms and finishes than any other. It has excellent forming and welding characteristics. The balanced austenitic structure of Grade 304 enables it to be severely deep drawn without intermediate annealing, which has made this grade dominant in the manufacture of drawn stainless parts such as sinks, hollow-ware and saucepans.

For these applications it is common to use special "304DDQ" (Deep Drawing Quality) variants. Grade 304 is readily brake or roll formed into a variety of components for applications in the industrial, architectural, and transportation fields. Grade 304 also has outstanding welding characteristics. Post-weld annealing is not required when welding thin sections. Grade 304L, the low carbon version of